SNOW SENSE

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SNOW SENSE

A Guide to Evaluating Avalanche Hazard

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INTRODUCTION

In the United States between 1950 and 1984, 276 people known to have died in 194 separate snow avalanche idents. An investigation of these accidents revealed that % were recreationists and that of these, over 80% were veling in the backcountry. A majority of the victims gered the avalanches that buried them.

The number of avalanche accidents continues to climb backcountry use increases, and more and more travelers h limited avalanche awareness access steep, mountous terrain. In Alaska alone during the 1983-84 season, re were at least 34 incidents involving 64 people. A dozen e injured and two died. Of the 64 victims, over 93% gered the slides that caught them.

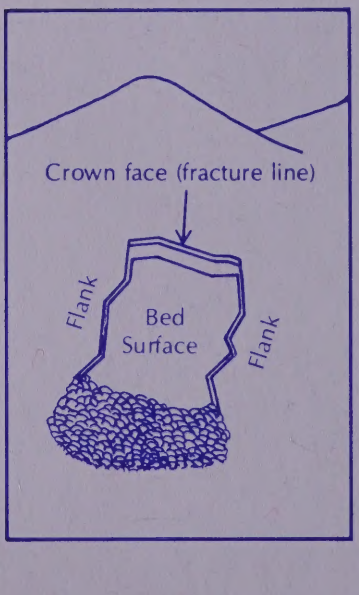
These statistics are meant not to intimidate but to cate. **The avalanches catching people are triggered by ple, and the same mistakes are being made repeatedly.** se mistakes are mainly the result of: 1) inexperience in ognizing and evaluating avalanche hazards, and 2) poor te selection. **Nearly all avalanche accidents can be ided. The clues are there—the key is to learn to read ure's "billboards."**

The goal of this booklet is to help you, as a backcountry eler, learn to **recognize, evaluate, and avoid** potential anche hazards. Ignoring available information is very h like trying to cross a busy boulevard with blinders on. street can be crossed safely, but only after taking the ders off and looking both ways.

FOUR MAIN THREATS TO TRAVELERS

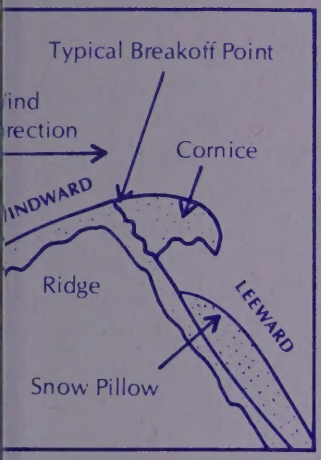
Loose Snow Slides

Loose snow slides start wi
a small amount of c
hesionless snow and ofte
pick up more snow as th
run. From a distance, they a
pear to start at a point and f
out into a triangle. They usua
ly involve only upper layers
snow.



Slab Avalanches

Slab avalanches occur whe
one or more layers
cohesive snow break away
a unit. Slabs vary in size fro
just a few inches to many te
of feet thick and similarly, va
in width from a few yards
over a mile. The slabs may
composed of either hard
soft snow. As the slabs trav
downslope, they break u
into either blocky or soft ar
powdery debris.



Cornice Breakoffs

Cornices form when wind-blown snow builds out horizontally at sharp terrain breaks such as ridgecrests and the sides of gullies. These cornices can break off well back from their edges. They often trigger bigger slides when they hit the wind-loaded, pillowed area on the slope below.

Ice Avalanches

Ice avalanches are caused by the collapse of unstable ice blocks (seracs) from a steep or overhanging part of a glacier. The hazard is usually easy to recognize but ice avalanches are unpredictable because an imminent ice fall cannot be detected.

The term avalanche pa
defines the area in which a
avalanche runs. An avalanch
path is generally divided in
three parts. The *starting zo*
is where the unstable snow
ice breaks loose and starts
slide. The *track* is the slope
channel down which sno
moves at a fairly unifor
speed. The *runout zone*
where the snow slows dow
and comes to rest. For lar
avalanches, the runout zo
can include a powder or wi
blast zone that extends f
beyond the area of sno
deposition.

EVALUATING HAZARD

This booklet will focus on slab avalanches since most
alanche accidents result from *human-triggered* slab
leases.

OW TO SEEK INFORMATION:

Is it safe or is it unsafe? That's the question you need to
swer before traveling on or near slopes capable of produc-
g avalanches. The essential problem you are faced with is
e of uncertainty; you just don't know whether the slope is
fe or not.

The key to eliminating or reducing uncertainty lies in
thering meaningful information upon which you can base
ur evaluation. Some of the most unambiguous information
ailable is in the form of clues provided by Nature. These
ues reflect on-going physical processes which affect the
bility of the snowpack. By choosing information that pro-
des a high degree of certainty and by seeking a variety of
ues that reinforce the message, you can quickly make an
aluation based upon meaningful information. This process
called the **bull's eye approach.** It means getting to the
art of the problem without getting bogged down in irrele-
nt information. On the following page is a chart showing
w this works.

THE BULL'S EYE APPROACH

Within this circle exists *all* of the information available to you whether meaningless or useful. Examples: The sky is clear and the temperature is 12°F (-11°C).

Within this area exists all of the data that is particularly *relevant* to your problem. Example: There is one foot of new, powder snow. Some of this snow is being transported by strong north winds.

Within this circle exists information that has a high degree of certainty. This information is highly *meaningful*. Example: South-facing slopes are avalanching due to heavy wind-loading. The presence of avalanche activity leaves little uncertainty in your mind about the potential hazard on south-facing slopes that have not yet released.

IN SEEKING INFORMATION,
GO FOR THE BULL'S EYE.

HAT INFORMATION TO SEEK:

The interaction of three main variables; the snowpack, ather, and terrain determines whether or not an alanche is possible. However, to determine whether an alanche *hazard* exists, we must add an important fourth iable, the mountain traveler. Without people or property, ere is no hazard.

The information needed to evaluate avalanche potential generally available to you. As you travel through the ountains, choosing routes or campsites, you need to swer the following four critical questions:

Could the snow slide?

Is the weather contributing to instability?

Is the terrain capable of producing avalanches?

Do safer alternatives exist?

The first step is to learn to recognize avalanche terrai because then you can make a conscious decision abou whether or not you want to expose yourself to possibl hazard. Factors determining whether a particular slop could produce an avalanche will be discussed in detail in later section but, in general, slope angle is the critica determinant.

If you decide that you do want to travel on or near stee slopes, then you must seek the key information needed t answer the questions above. By doing so, you can begin t base your hazard evaluation upon solid facts rather tha assumptions, feelings, or guesses.

WHEN TO SEEK INFORMATION:

The snow stability evaluation process should start *befor* you leave on your proposed trip. Gather information abou recent weather and snow conditions from availabl resources such as an Avalanche Forecast Center or th National Weather Service. As you approach the area you wi be traveling in, look for clues pointing to important recen events such as strong winds, new snowfall, and avalanch activity. Begin to formulate an opinion based upon you observations of key data and *continually* seek to support o refute that opinion with additional information. **Stay con stantly alert for clues**. Be objective; don't let your desire t reach a goal interfere with your evaluation.

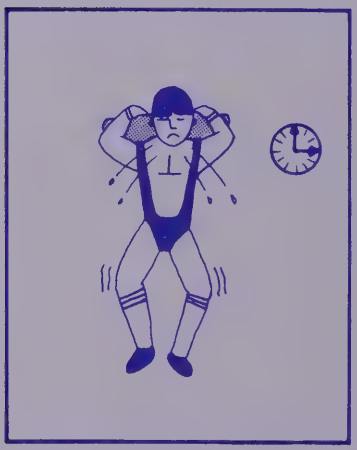
COULD THE SNOW SLIDE?

The snowpack accumulates layer by layer with each new now or wind event. These layers are then subject to changes texture and strength throughout the winter. The changes elp determine snow strength by influencing how well dividual snow grains are bonded (attached) to each other oth within a layer and between layers. Some layers are rong, others are weak. Strong layers tend to be made up of ell-bonded, small, rounded grains. Weak layers are made p of poorly bonded or cohesionless grains. A thin weak yer can be created simply if one layer is poorly bonded to nother. Many combinations of weak and strong layers can xist within the snowpack.

Do not be misled by the terms weak and strong. Strong oes not necessarily mean stable. A strong layer is cohesive nough to fail initially as a slab. Slab avalanche potential xists when relatively strong, cohesive snow is underlain by eaker snow or is not bonded well to the underlying layer.

In a stable snowpack, the strength of the snow is greater an the stress exerted on it. For an avalanche to occur, mething must *upset* this balance so that the stress on, or ithin, the snowpack becomes equal to its strength. The alance can be tipped either by 1) an increase in stress or 2) a ecrease in strength.

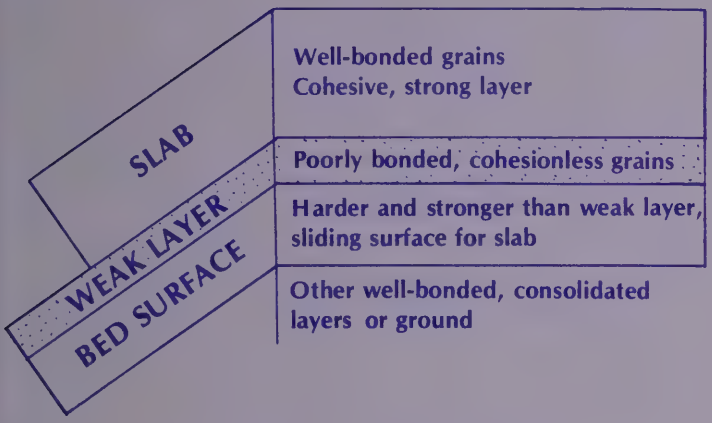
In the first case, imagine a strong man on whose shoulders we place a 100-pound sack. If we want to get the man to collapse and "fail" we merely have to pile more sacks on him until he can no longer hold them. This is similar to a snowpack that fails with the additional stress of new snow loading, wind loading, or the weight of an unsuspecting mountain traveler.



In the second case, we can illustrate failure by loading a 100-pound sack on the shoulders of the same strong man and seeing how long he can stand before his knees collapse. This is similar to weakening of the snowpack through internal changes.

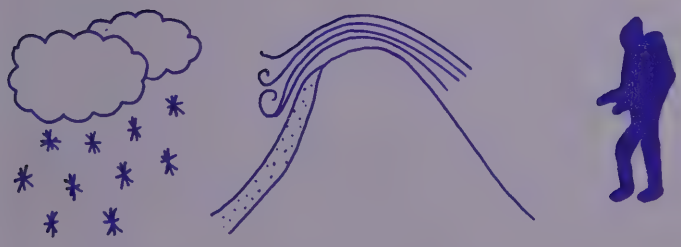
The snowpack can adjust only to a certain amount of stress and then only at a certain rate. **When stress equals strength, failure occurs.**

INGREDIENTS FOR A SLAB AVALANCHE



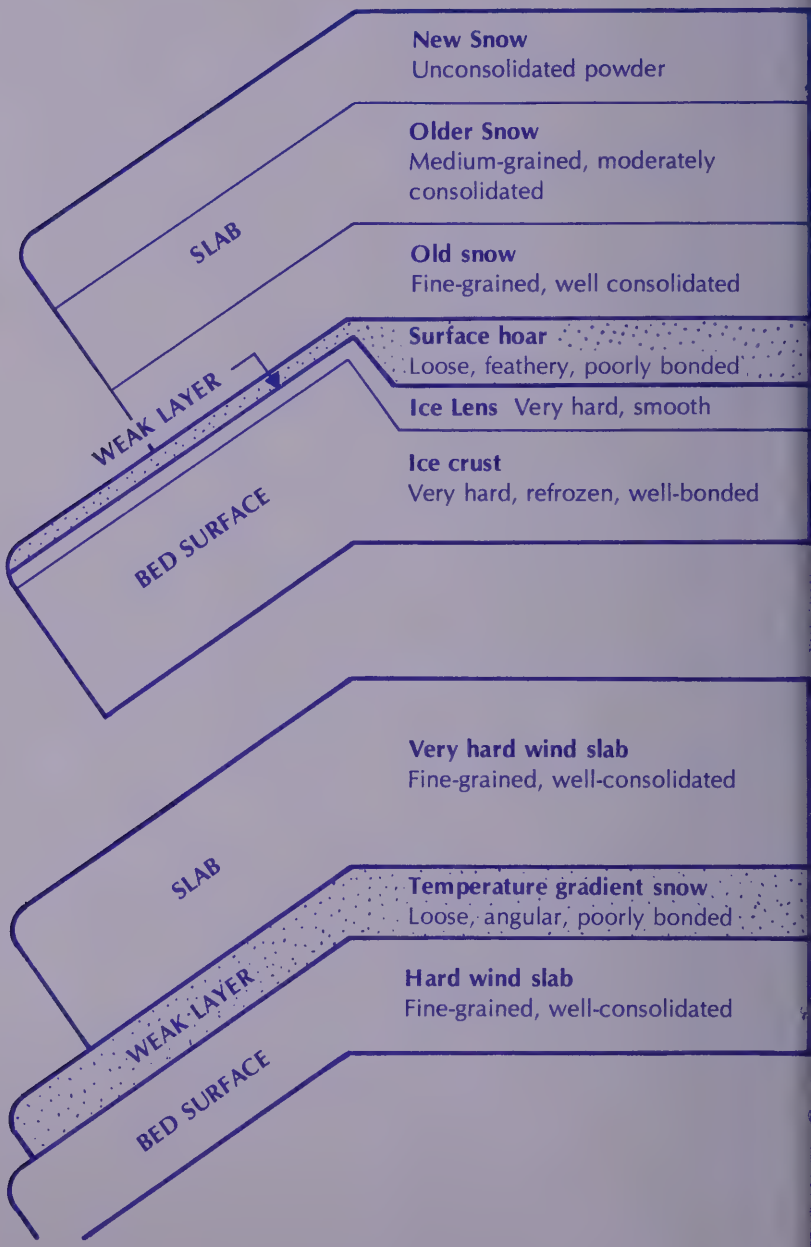
UNSTABLE SNOW STRUCTURE + SOMETHING TO TIP THE BALANCE

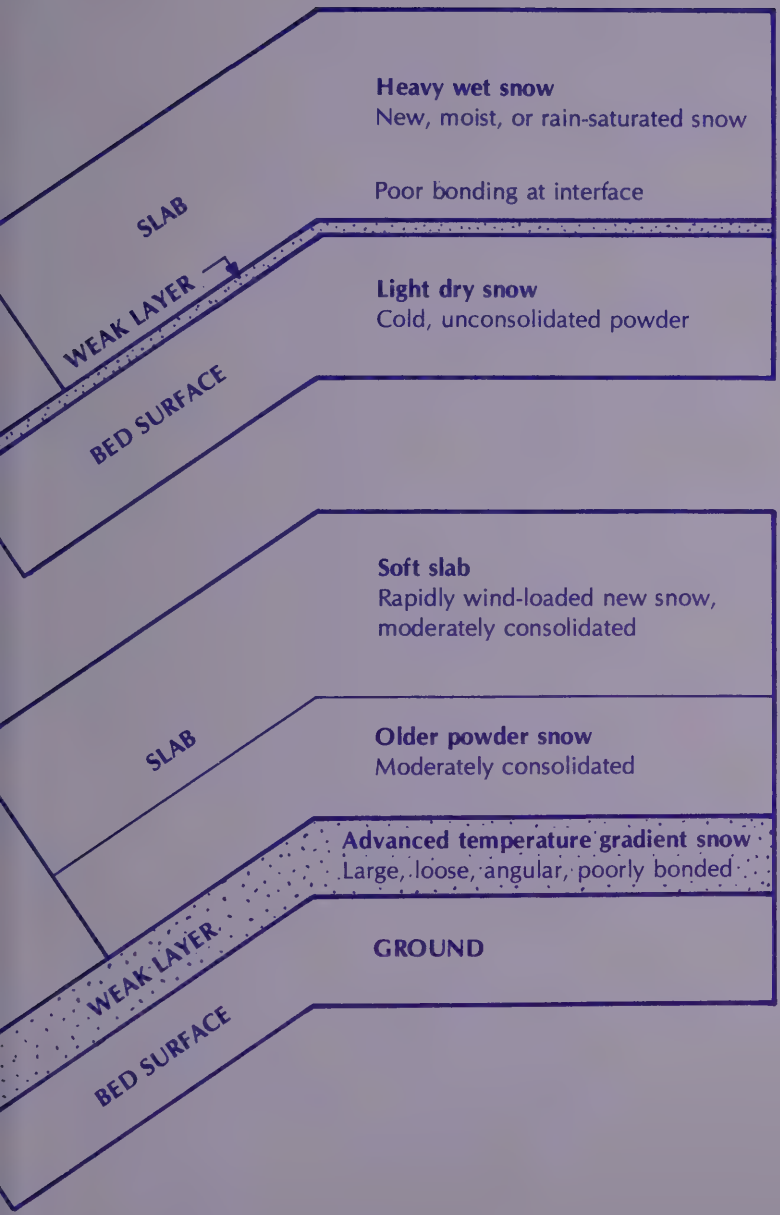
AVALANCHE!



Avalanches Do Not Happen By Accident!

TYPICAL UNSTABLE SNOW STRUCTURES




Heavy wet snow
New, moist, or rain-saturated snow
Poor bonding at interface
SLAB
WEAK LAYER
Light dry snow
Cold, unconsolidated powder
BED SURFACE
Soft slab
Rapidly wind-loaded new snow, moderately consolidated
SLAB
Older powder snow
Moderately consolidated
Advanced temperature gradient snow
Large, loose, angular, poorly bonded
WEAK LAYER
GROUND
BED SURFACE

FIELD OBSERVATIONS AND TESTS

Unstable snow structures can be detected! **Be alert: look, listen, and feel for these bull's eye clues.**

NATURE'S "BILLBOARDS"	THE MESSAGE
Recent Avalanche Activity on Similar Slopes	This is a clue with a lot of certainty. Avalanche potential is very likely to exist on slopes with similar orientations and angles that have not yet slid.
Recent Wind-Loading	Evidence of windblown snow includes smooth "pillows", cornices, and drift patterns on the snow surface and around trees. Such wind-loading increases the stress exerted on the snowpack. Suspect instability on wind-loaded, lee slopes!
Hollow Sounds	These hollow, drum-like sounds indicate unstable slab conditions. Investigate. You might find you are traveling on wind slab over temperature gradient snow.
"Whumphing" Noises	Distinctive settling noises or 'whumphs' are the sounds made when a weak

layer collapses within the snowpack. Extreme instability exists. Nature is screaming in your ear!

Shooting Cracks

Cracks shooting out in the snow around you provide direct evidence of instability.

Get into the habit of *testing* the layering and bonding of the snow. **No one test will tell all—you must piece together the story the snowpack is trying to tell.** Bull's eye questions: Is there a slab? What is its depth and areal extent? How well is it bonded to the layers beneath? What will it take to make the slab fail? Here are some ways to get the information you need to answer these questions:

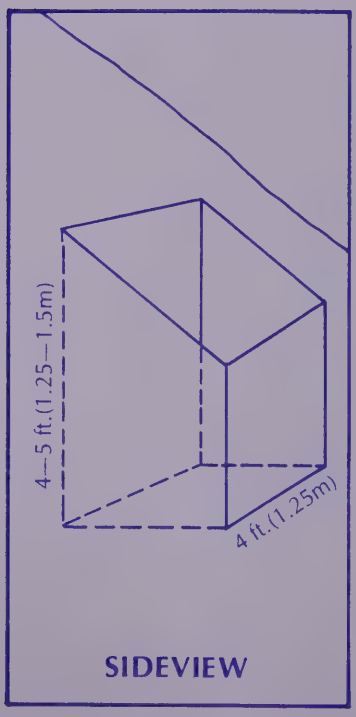
CAUTION: Never conduct the following tests in a location where you might trigger a slide with serious consequences to yourself or others.

SKI POLE TEST (2-3 min)

This test is quick and should be done often as you travel. Holding your ski pole at a right angle to the snow surface, push the handle end into the snowpack. Feel the relative hardness and thickness of the layers. Be alert for well-consolidated layers that feel harder than underlying soft, weaker layers. Probe in several different spots.

Now widen the hole with your pole using circular motions. Reach into the hole and, with your fingers, feel how hard or soft each layer is.

One serious limitation of the ski pole test is that sometimes the weak layers are too thin to detect by this method. Another is that it tells you little about how well the layers are actually bonded to each other except in cases of extreme instability.



SHORT SNOWPIT (10-20 min)

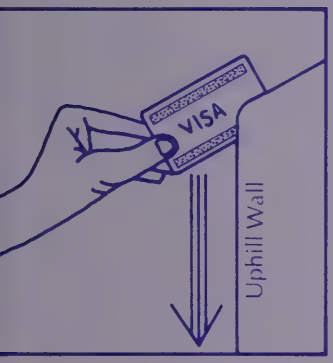
Choose a spot with conditions similar to those you are evaluating. In other words, select a site that has roughly the same elevation, snow conditions, slope angle, and aspect as the slope you are concerned about. Balance safety with realism.

Now dig a pit 4-5 feet (1.25-1.5 meters) deep and wide enough for you to work in (approximately 4 feet or 1.25 meters). As you shovel, pay attention to changes in snow texture indicating weak and strong layers. Be careful

not to disturb the snow surface or pit wall on the uphill side of the pit. Smooth off this wall with the back of your shovel. The uphill pit wall is where all your tests will be conducted.

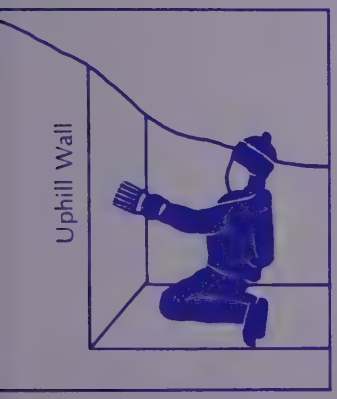
NOTE: Most human-triggered slab releases occur within a depth of 4-5 feet (1.25-1.5 meters). It is not necessary to dig to the ground unless you suspect deep slab instability.

IDENTIFY LAYERS



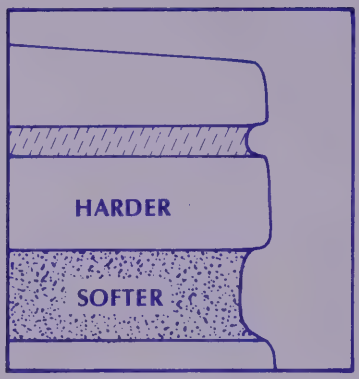
Resistance test

Insert a credit card or knife into the top of the uphill pit wall and at the same angle as the slope. Run the card vertically down the wall, feeling the relative resistance of the layers and noting the boundaries of hard and soft layers.



Stratigraphy test

Using a wisk broom, paint brush, hat, or mitten, lightly brush the uphill pit wall with uniform, horizontal strokes. This will quickly transform the wall from plain white into a layered mosaic of snow history. The layers of the snowpack will be revealed in a series of ridges and valleys.



The raised or ridged surfaces indicate the harder, stronger layers that may be possible slabs or sliding surfaces. The valleyed surfaces reveal softer, weaker layers.

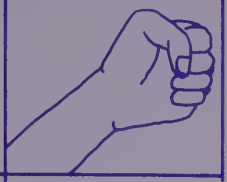
Hardness Test

Test the relative hardness of each layer by gently pushing your hand into the pit wall. One layer might be so soft that you can easily push your whole fist into it while another might require a knife to penetrate it. Layer hardness can be classified as fist (very soft), 4-finger (soft), 1-finger (medium), pencil (hard) or knife (very hard). An example of a potentially unstable slab configuration would be a cohesive "1-finger" hard layer resting on top of a less cohesive "fist" hard layer. This, in turn, could be underlain by a harder bed (sliding) surface with a hardness ranging anywhere from "4-finger" to "knife".

Remember that the strength of a layer is determined by how well the grains within it are bonded to each other. While strong layers are often hard and weak layers are often soft, note that this is *not* always the case. New, powder snow can form cohesive slabs despite the fact that it might only be fist hard.

These tests yield a good visual representation of strong and weak layers, but still do not indicate how well the layers are bonded. To check this you must conduct the shovel shear and jump tests. Such tests are critical because often they will reveal a previously undetected but serious weakness in the snowpack created by poor bonding between layers.

DEGREE OF HARDNESS CHART

Very Soft	Fist(F)	
Soft	Four fingers(4F)	
Medium	One finger(1F)	
Hard	Pencil (P)	
Very Hard	Knife (K)	

Note: Test usually done with a gloved hand.

TEST LAYER BONDING

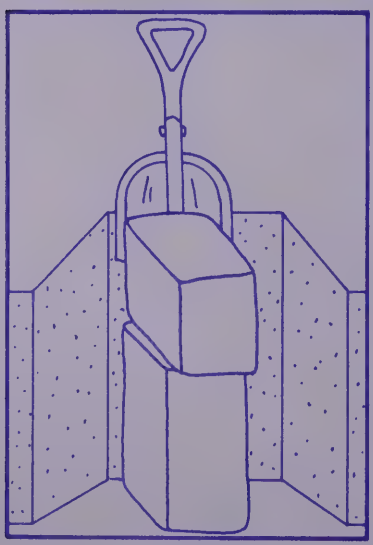
Shovel shear test

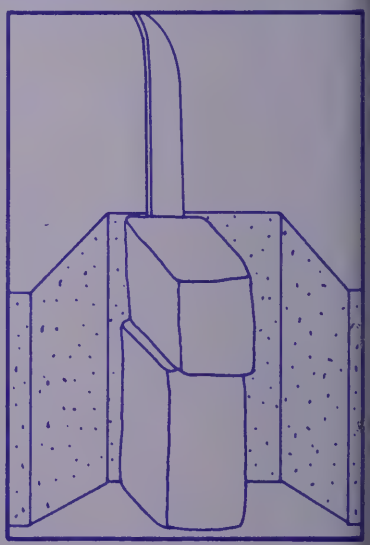
Isolate a column along the back of the pit wall by cutting away the sides with a shovel. The width of this column as well as the depth cut into the pit wall should be approximately equal to your shovel width. Cut the back of the column where it connects to the pit wall by sawing downward with a snow saw or string. Now slowly insert your shovel or ski (tip up and binding facing upslope) at the back of the column

and pull gently forward. Slab layers will usually break off along a clean plane. The ease with which they break is an indicator of how poorly the layers are bonded. If you barely touch the shovel or ski to the column and a layer shears off, the snowpack is very tender (unstable), with very poor layer bonding, and likely to fail. On the other hand, a column that has to be pried, hammered, and levered loose is a pretty good indication of a stable, well-bonded snowpack.

The ease with which a column shears is rated as very easy, easy, moderate, hard, or very hard. Generally, "very easy" and "easy" shears are considered indicators of unstable snow while "moderate", "hard", and "very hard" shears reflect varying degrees of a stable snowpack. **But remember, stability is relative to the amount and rate of stress exerted on the snowpack.** A "moderate" shear on a 30° slope might be an "easy" shear on a 45° slope because the snow on the steeper slope angle is subjected to greater stress. A slope that may be safe for 2 skiers may release when a third person crosses. **Leave a wide margin of safety.**

Two Methods of Performing Shear Test





Jump test

This test is a fun means of applying extra force to the snowpack to see if it will fail. With a snow saw, ski or string, cut an arch or a pie-shaped wedge into the snow surface above the uphill pit wall. Be careful not to disturb this area with your footprints or ski tracks.

Stand above the cut area and take a flying leap onto the upper edge of the arch or wedge. See if you can make a slab layer slide into your pit. A very unstable snowpack will fail easily—perhaps even before you jump. A stable snowpack will either not fail or require repeated efforts.

This test is also a great way to fill in your pit, keeping the slopes safe for others!

These tests allow you to obtain a maximum amount of snowpack information in a minimum amount of time. It is your responsibility to *integrate* your observations with other snowpack clues as well as with weather and terrain information.

IS THE WEATHER CONTRIBUTING TO INSTABILITY?

Most natural avalanches occur during or shortly after storms because the snowpack often cannot adjust to the vast amounts of new weight added in a short time. Consider how each of the following factors affects the critical balance between strength and stress within the snowpack.

PRECIPITATION

New snow adds weight, which increases stress. Wet snow is heavier than dry snow. Snow can also add strength through whatever bonding is taking place.

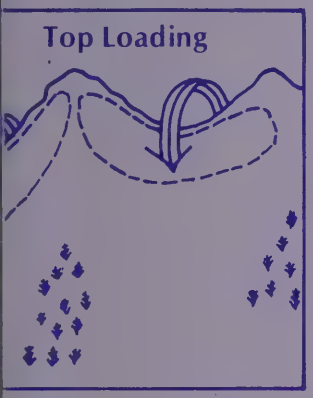
Rain adds weight, but not strength. Heavy rain can greatly increase the stress on the snowpack and make the snow highly unstable. Rain also helps weaken layers by eroding the bonds between grains. Another danger of rain is that it often produces icy crusts. These crusts can make excellent bed (sliding) surfaces for future snowfall. Though a wet snowpack may be very unstable, note that it becomes very stable and strong when refrozen.

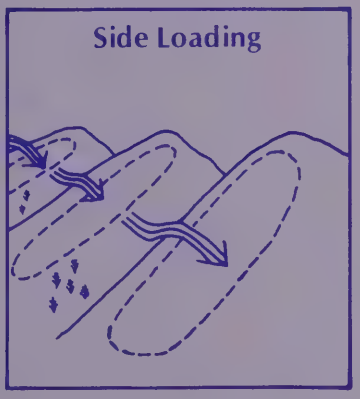
How quickly is the loading occurring and how much total new weight is being added? The more rapid the loading, the less time the snowpack has to adjust to the additional stress. All things being equal, one foot of snow falling in eight hours is more likely to create unstable conditions than one foot falling over three days. Add wind and the problem is rapidly compounded.

IND

Wind can redistribute snow by scouring windward pes while loading leeward terrain and creating cornices. nd-transported snow generally forms compact, well- nded layers and thus makes good slab material.

Wind direction is important because it determines which pes are being loaded. For instance, strong southeasterly nds will load north- and west-facing terrain. Wind loading mmonly occurs two ways. Top loading takes place when wind blows over the top of a ridge, depositing snow just ow ridge level. Generally, the stronger the wind, the ther downslope the snow is deposited. Side-loading curs when the wind blows across a slope, loading it from to right (or vice versa) on the leeward side of ridges or lies bisecting the slope.





te that while leeward slopes are becoming more unstable e to increasing load, the stress on windward slopes is creasing as the snow is stripped off. For this reason, wind- rd slopes generally make good routes. Beware, however, cause wind shifts in the mountains are common. Today's ndward slopes may have been wind-loaded yesterday en they were on the leeward side of the prevailing wind.

The wind speed required for wind-loading depends par
ly on the snow surface. New, light, powder snow is mor
readily transported than hard-packed old snow. Wind inte
sity and duration influence how quickly and how muc
stress is added or relieved on a given slope.

TEMPERATURE EFFECTS

Air/Snow Temperature

Changes in snow temperature affect snow stabilit
These changes are governed largely by changes in a
temperature and by solar radiation. The warmer th
snowpack, the more rapidly changes within it occur. A war
snowpack (warmer than 25°F or -4°C) ordinarily settl
(compresses) rapidly, becoming denser and stronger. In
cold snowpack, unstable snow conditions often pers
longer because the settlement or strengthening process
slowed. The snowpack may actually weaken with time
there is a marked difference in temperature betwee
snowpack layers, for example, between the insulated war
snow at depth and the colder layers near the surface. Such
temperature difference favors the development of wea
layers of temperature gradient snow, particularly in low de
sity snow. Well-developed temperature gradient snow
called depth hoar or sugar snow.

Air temperature trends during a storm are also impo
tant. Storms that start out cold and get progressively warme
are more likely to produce avalanches. The fluffy cold sno
that falls early in the storm often bonds poorly to the o
snow surface and is not strong enough to support the heav
denser snow deposited on top of it. Any rapid, marke
change in temperature, particularly an increase, can lead
instability and should be noted as one of Nature
"billboards".

olar Radiation

Solar radiation is a double edged sword. On the one and, warming in moderation encourages stabilization hrough settlement. On the other, intense warming, which ccurs especially during the spring in northern regions, can nake the top layers of snow wet and heavy and weaken the onds between grains. This often results in loose snow avaanches and cornice breakoffs which, in turn, may trigger eeper slab releases as they move downslope. A slope that is table in the morning may produce avalanches in the afternoon.

Direct sun is not the only hazard. Weak layers tend to persist longer on north-facing and shaded slopes where the snowpack has not undergone as much settlement due to warm sun and where temperature gradient snow development is often enhanced.

Sky cover

Periods of cold, clear, calm weather encourage the growth of surface hoar on the snow surface. These light feathery crystals can be thin, deadly, weak layers when later buried. These conditions are also favorable for development of temperature gradient snow deeper in the snowpack. Periods of cloudy, moderate weather may warm the snowpack, helping it to settle and eventually become stronger. Although these periods may lead to greater stability, avalanches often occur during the warming process.

EXAMPLES OF TYPICAL WEATHER PATTERNS RESULTING IN UNSTABLE SNOW CONDITIONS

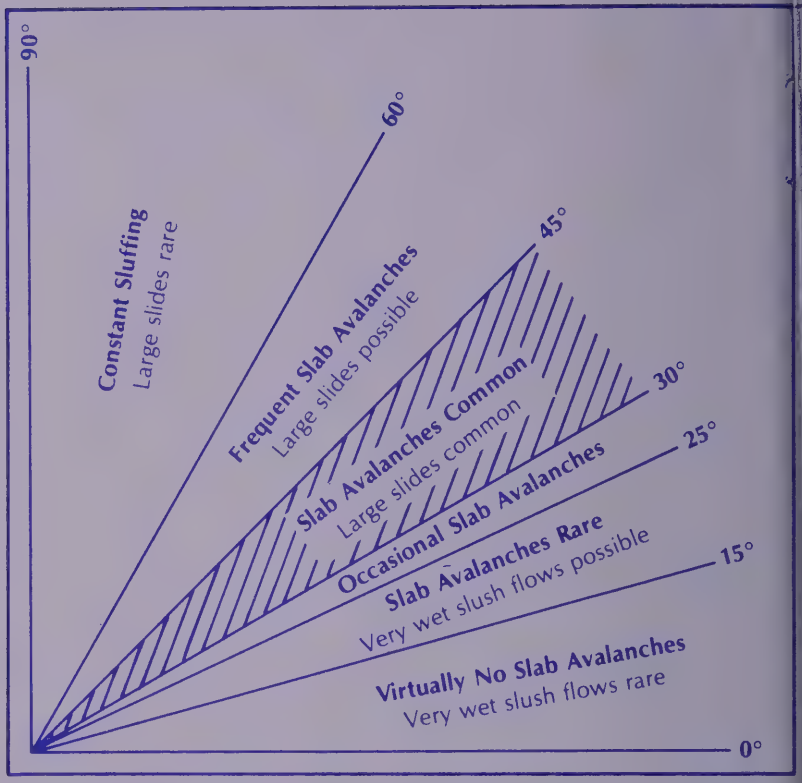
- Heavy amount of snow loading in short period
- Storm that begins cold, ends warm
- Heavy rain
- Long, cold, clear, calm, period followed by heavy new snow or wind-loading
- Rapid temperature rise after long cold period
- Intense solar radiation
- Significant wind-loading

IS THE TERRAIN CAPABLE OF PRODUCING AVALANCHES?

Learning to recognize avalanche terrain is the critical first tep in hazard evaluation. Many people who have been aught in avalanches did not even recognize the hazard until : was too late. A common mistake is to assume that valanches occur only on the large, obvious paths and to ignore the small terrain traps just beyond the parking lot. Another is to assume that it is safe to travel along the valley bottoms without considering whether you could be caught n a avalanche that releases on the slopes above. The following factors influence whether a given slope is capable of producing an avalanche and will help you recognize avalanche errain.

Slope Angle

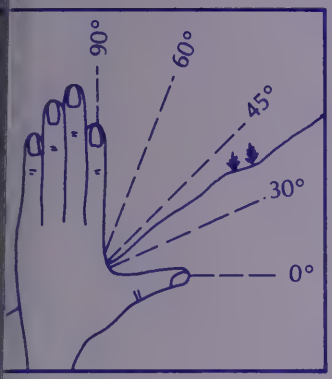
Slope angle is a *critical* variable determining avalanche potential. Slab avalanches are possible only within a certain range of slope angles, *generally* between 25° and 60°. The word generally is highlighted because this range is variable and depends on a number of factors including climate. Above 60°, the stresses on the snowpack are so great that the snow tends to continually sluff off. Below 25°, the stresses on the snowpack are usually not great enough to cause the snow to slide although in warm, very wet snowpacks, avalanches have occurred on slopes of less than 20°. **The majority of slab avalanches start on slopes and in gullies with angles between 30° and 45°.**



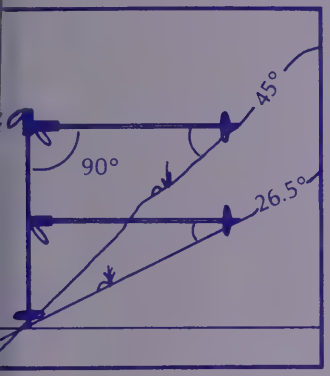
Remember: As the slope angle increases, so does the stress exerted on the snowpack.

An important thing to remember is that you can trigger an avalanche from below even if you are traveling across a 12° slope, as long as the upper part of the slope has an angle of *at least* 25° and instability exists.

Continually ask yourself, "is the slope steep enough to slide?" **It is critical to judge slope angles correctly.** Perhaps the most reliable means is to purchase an inexpensive clinometer or slope meter. See the accompanying diagrams for an explanation of how you can also use your hand or ski poles to estimate slope angle.



Holding your index finger and thumb at a right angle, line up the slope in the apex of your hand. If the slope divides the apex in half, the slope is approximately 45°. The slope is roughly 30° or less if the slope divides the apex in the lower third and 60° or more if it divides it in the upper third.

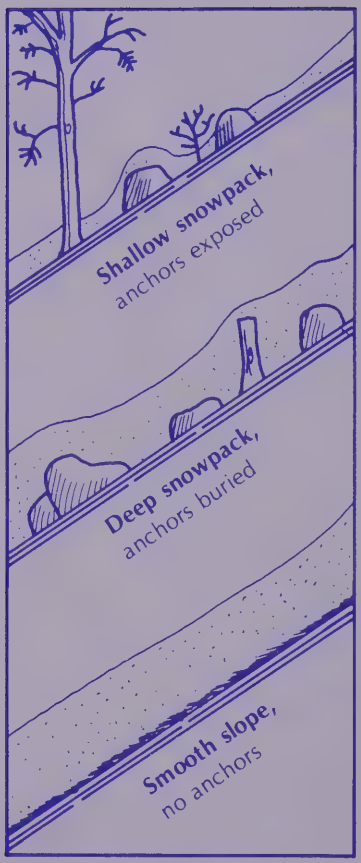


This method works best if you premark your ski poles into 10 equal sections. In the above diagram, when the pole held horizontally to the snow surface meets the vertical pole in the midsection, the angle is 26.5°. When the two handles are touching, the angle is 45°. Thus, a 10:10 (or 1:1) ratio between the markings on the poles is a 45° angle; a 6:10 ratio is a 30° angle; and a 5:10 ratio is a 26.5° angle.

Slope Orientation

Which direction is the slope facing relative to both recent winds and the sun? Subtle changes in slope orientation (aspect) can greatly affect snow stability. **Be suspicious of leeward slopes** because of the additional stress exerted by wind-loaded snow. Cornices and snow pillows develop on leeward aspects.

Remember that while warming can help stabilize a slope, intense, direct sun can have the opposite effect. Also remember that weak layers often persist on shaded slopes.

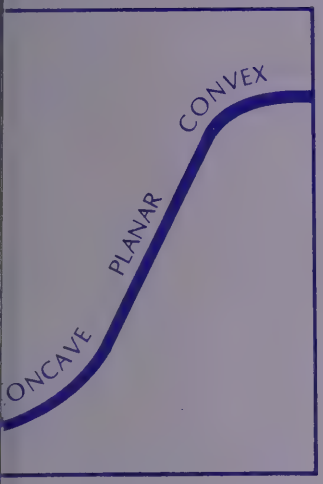


Terrain Roughness

Boulders, trees, and ledges act as anchors and help hold the snow in place until the anchors themselves are buried. Slopes with anchors are less likely to avalanche than open slopes, but the anchors have to be almost too close together to walk through to ensure that an avalanche cannot occur. Furthermore, anchors can be areas of stress concentration because the snow upslope of them is being held in place while the snow to the sides is being pulled downhill by gravity. Thus, stress on the snowpack can be greatest near terrain features. For this reason, they can be starting points for initial failure to occur.

Slope Configuration

Avalanches can happen on any snow-covered slope steep



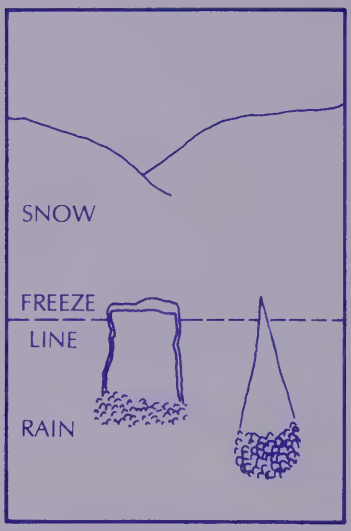
enough to slide. On convex slopes, slabs are most likely to fracture just below the steepest part of the bulge where stresses are greatest. On broad, smooth (planar) slopes, avalanches can happen anywhere. Slabs often fracture below cliff bands. Concave slopes provide a certain amount of support through compression at the base of the hollow, but they are still quite capable of avalanching, especially on large slopes.

Vegetation

Vegetation can provide many indicators of past avalanche occurrences and thus potential avalanche terrain. These indicators include:

- Swaths of open slope between forested or vegetated areas
- Bent or broken trees, vegetation 'flagged'' (e.g. missing branches) on the uphill side
- Presence of ''disaster species'' such as alders, willows, dwarf birch, and hemlock

- Marked difference in heigh of trees (e.g. smaller spruc in the path, larger on th edges)



Elevation

Temperature, wind, an precipitation often var significantly with elevation Common differences are rai at lower elevations with snow at higher elevations (deter mined by freezing level) or di ferences in precipitatio amounts or wind speed wit elevation. **Never assume tha conditions at one test site wi reflect those at another eleva tion.**

Path History

Every avalanche path has history. It is not a question of the path will produce a avalanche but rather when under what conditions, an how big. Learn about the pat history of the area where yo are traveling, not only b seeking clues at the site bu also by talking wit knowledgeable travelers avalanche specialists, par rangers, and local peopl familiar with the area.

ne product of avalanche terrain recognition should be
l route selection. **Utilize the terrain to your advantage.**
xample, favor the windward sides of ridges, avoid lee
s, and stay well out in the valley bottoms away from
nche-producing slopes. You can become an avalanche
by:

noring slight but significant increases in slope angle.
aveling on gentle slopes with steep slopes above and
azardous terrain such as cliffs and ravines below.
verlooking changes in snow conditions caused by wind
sun due to variations in slope orientation.
ossing a slope at a high stress point such as a convex
ulge.
ssuming tree-covered slopes are safe.
aveling on top of or underneath cornices.

And finally, recognize that sometimes *there may be no route*. You should also recognize, however, that if instability is suspected on a route which absolutely *must* be ended, you may have the option of trying to make the e avalanche before you trigger a waiting trap. There are ral ways to try to cause slab failure. These include rolling rocks onto the path and conducting a belayed jump n the upper part of the starting zone. These tests are gerous and must be conducted from a safe location to re that you are not caught if you do indeed succeed in ering an avalanche.

MOUNTAIN TRAVELER
(Decision-Making)

DO SAFER ALTERNATIVES EXIST?

Most recreationists *allow* avalanche accidents to happen because they do not know how to recognize, evaluate, and avoid avalanche hazards. You must "think avalanche" whenever you are on or near steep snow slopes regardless of the slope size or time of year. The key to safe winter travel is sound decision-making. Such decision-making requires that you: 1) identify the problem, 2) explore your alternatives and their possible consequences, 3) collect and evaluate bull's eye data, 4) make a decision followed by action. Let's take a closer look at these decision-making components:

Identify the Problem

Imagine that you and three others are heading along a safe ridge route towards a mountain pass. After several hours of traveling, you find that the ridge terminates at a steep, snow-covered slope that is a potential avalanche path. You do not know whether the slope is safe to cross or not. The problem rapidly begins to complicate itself when other impending factors such as group fatigue, approaching darkness, group pressure, and deteriorating weather come into play.

Explore Your Alternatives and Their Possible Consequences

You and your group have the option of continuing on, staying put, backtracking, or choosing an alternate route. You also have the option of doing any of the above in haste or after careful consideration. You need to evaluate the possible consequences of each alternative, that is, your

hances of success versus your chances of getting caught, uried, or killed. You must seek out key information so that ou can objectively evaluate the hazard, weigh your options, nd choose the safest alternative.

ollect and Evaluate Bull's Eye Data

In order to thoroughly explore your alternatives, you eed to collect key information about the snowpack, eather, and terrain. Look, listen, and feel for nature's clues. emember to seek information with a high degree of certain- in its message. Facts, observations, and tests are the foun- ation of sound decision-making. Base your evaluation on nore than one input and *continually* seek to support or efute it with additional data.

Your hazard evaluation is only as good as the data it is ased upon. Your decisions must be founded upon *facts and bservations* rather than assumptions or feelings. Most valanche accidents occur as a result of faulty assumptions. xamples of such assumptions include:

"The snow ranger said the hazard was low-moderate so we didn't expect to get caught."

"We followed the tracks of another party up the mountain because we figured that if they made it, so could we."

"We were wearing rescue beacons so we assumed we would be safe even if we got caught in an avalanche."

"We planned the trip for three years and we weren't about to throw it all away because of one storm."

There is an important lesson to be learned from these assumptions. Nature doesn't care about our beliefs, schedules, or goals. In each of the cases above, the victims ran into trouble because they presumed that a situation was safe or rationalized their decisions. We need to remember that what may seem important to us may not be important to Nature. Your safety in the mountains requires that you evaluate avalanche potential from Nature's perspective.

Make a Decision Followed By Action

Sound decision-making demands good communication between group members. Exchange information and suggestions freely. Evaluate each others assumptions. If necessary, say "no, I don't think we should follow that route because..." Equally important, learn to accept a "no" from another group member. A "no" based upon fact is a very powerful tool with which to save lives.

Continually strive to supplement your hazard evaulation with new information. You must remain alert because the snowpack is not static. **Snow stability can change within a matter of minutes.**

SUMMARY

Avalanches do not happen without reason. Only by seeking, evaluating and acting on the information available to us can we *prevent* avalanches. A summary of bottomline questions that need to be asked and answered when evaluating avalanche hazard follows. Note that the terrain questions should be asked first because if you are *sure* that the terrain cannot produce avalanches, then you have nothing to worry about. Conversely, if you recognize that you are traveling on or near avalanche terrain, then you have the chance to evaluate and, if necessary, avoid the hazard before you are surprised by it.

1. **Is the slope capable of producing avalanches? (terrain analysis)**

   Critical factors:

   - Slope Angle (Is the slope steep enough to slide?)
   - Slope Orientation (How are the sun and wind affecting slope stability?)
   - Terrain Roughness (How well anchored is the snowpack?)

2. **Could the snow slide? (snow stability evaluation)**

   Critical factors:

   - Layering (Does a slab overlie a weak layer?)
   - Bonding (How well are the layers bonded to each other?)
   - Strength/Stress (How much stress will it take to make the slab fail?)

3 . **Is the weather contributing to instability? (past and present weather conditions)**

Critical factors:

- Precipitation (What is the type, amount, and intensity of precipitation being deposited?)
- Wind (How much snow is being transported and where is it being loaded?)
- Temperature (What effects are past and present temperature having on the snowpack?)

4 . **Do safer alternatives exist? (decision- making)**

Critical factors:

- Problem Recognition (What is the problem? What are your alternatives and their possible consequences?)
- Data Collection (What key information concerning the snowpack, weather, and terrain have you gathered?)
- Hazard Evaluation (What assumptions are being made? What facts, observations, and tests are you basing your decision on?)

If the answer to any of the four major questions is 'yes', then you would be well advised to go somewhere the answer is 'no'.

ADDITIONAL TIPS

f you travel alone or without essential safety equipment, ou are greatly limiting your chances of survival if caught in n avalanche.

Carry necessary rescue equipment.
Use the terrain to your advantage.
Use safe crossing procedures.
Have a rescue plan.

escue equipment

All members of a party should carry and know how to use:

- Avalanche rescue transceiver (beacon)
- Avalanche probe or probe ski poles
- Shovel
- First aid kit

se the terrain to your advantage

- Pay attention to slope angles. As the angle increases, so does the stress exerted on the snowpack.
- Travel on ridges, especially the windward sides.
- Stay well out in the valley floors, away from avalanche-producing slopes.
- Avoid wind-loaded, lee slopes.
- Favor terrain with anchors, e.g. tree-covered areas over open slopes.
- Avoid slopes that end in terrain traps such as cliffs or ravines.

Safe crossing procedures

- Do not assume safety because of prior crossing or use of these procedures.
- Prepare yourself *before* crossing. Tuck in clothing, loosen pack straps and waist belt, remove ski pole and safety straps.
- Cross one person at a time with all other members of the party watching from a safe position. Never travel closely bunched together.
- Travel quickly, from one safe location to another, in order to minimize your exposure time.

Rescue plan

AS A VICTIM:

- If you are caught in an avalanche, call out so other members of your party know to watch you as you are carried down the slope.

- If possible, discard cumbersome gear such as skis, ski poles, and pack.

- Use a swimming and rolling motion to try to stay on the surface of the snow and work your way to the side of the avalanche. Fight with all your effort.

- As you feel the snow slow down, thrust your hand or any part of your body above the snow surface so it can be seen by others.

- Before the snow settles, cup your arm in front of your face to clear an air space.

- If buried, relax to preserve oxygen. **Do not panic!**

S A RESCUER:

- Watch the victim as he is carried down the slope. If he disappears under the moving snow, keep your eyes fixed on the mass of snow he was enveloped in, until it comes to rest. The victim may be under the snow surface in that area.

- STOP = stop, think, observe, plan. **Do not panic!** You are the victim's best chance of survival now. **STAY ON SITE AND SEARCH. ALMOST ALL HOPE OF A LIVE RESCUE DEPENDS ON YOU.** A victim has only a 50% chance of survival if buried more than 30 minutes. Outside help cannot usually arrive fast enough.

- Before entering the search area, make sure there is no further avalanche danger and pick a quick escape route. Take a few moments to organize the search party.

- Mark the points where the victim was first caught and was last seen above the snow. Search for and mark other clues beneath the last seen point.

- If the victim is wearing an avalanche beacon, conduct a search pattern with your beacon on receive. If party members have avalanche beacons and know how to use them, the victim can be found very quickly. However, a beacon is *not* a safety talisman—the victim can still be injured or killed during the slide. You also need a shovel so that the victim can be dug out quickly.

- If the victim is not wearing a beacon, randomly probe the debris in likely catchment areas first (e.g., areas of greatest deposition, near exposed obstacles, along the sides of the path, and at abrupt changes in slope).

- If the victim is not located after the initial visual search and random probe, begin a coarse probe in the most likely catchment area. Spread out, in a horizontal line, with rescuers elbow to elbow. Probes should be held vertically and directly in front of each person so that the probes are 30 inches apart. Advance upslope 24 inches at a time. Continue coarse probing until there is no hope of a live rescue.

- **Remember time is critical. Search quickly and effectively.** Dig the victim out *carefully*. Administer appropriate first aid. Treatment for suffocation, hypothermia, dehydration, and shock is commonly required after avalanche accidents.

FURTHER INFORMATION

he below lists are not comprehensive, but they are a start.

ecommended Reading

)affern, T. 1983. *Avalanche Safety for Skiers and Climbers*. ocky Mountain Books, Calgary, Alberta, Canada.

aChapelle, E.R. 1978. *The ABC of Avalanche Safety*, Mountaineers, Seattle.

erla, R.I. and M. Martinelli, Jr. 1978. *Avalanche Handbook*. evised edition. U.S. Department of Agriculture Handbook 89, U.S. Government Printing Office, Washington, D.C.

Villiams, K. 1981. *The Snowy Torrents, Avalanche Accidents n the United States 1967-71*. Second edition. Teton ookshop Publishing Company, Jackson, WY.

Villiams, K. and B. Armstrong. 1984. *The Snowy Torrents, valanche Accidents in the United States 1972-79*. Teton ookshop Publishing Company, Jackson, WY.

valanche Hazard Evaluation Training

laska:

Alaska Avalanche School
Alaska Department of Natural Resources
Division of Parks and Outdoor Recreation
Pouch 7-001
Anchorage, AK 99510
(907) 276-2653

Continental USA/Canada:

American Avalanche Institute, Inc.
P.O. Box 308
Wilson, WY 83014
(307) 733-3315

National Avalanche School
2638 Dapplegray Lane
Walnut Creek, CA 94596-6699
(415) 937-9338

Sierra Avalanche Seminars
P.O. Box 8
Norden, CA 95724
(916) 587-1593

B.C.I.T. Avalanche Program
3700 Willingdon Avenue
Burnaby, B.C., V5G 3H2, Canada
(604) 434-5734

Mountain Weather and Snow Stability Information

Alaska:

Alaska Avalanche Forecast Center
701 C Street, P.O. Box 23
Anchorage, Alaska 99513
(907) 271-5099

24-hour conditions recording,
Southcentral Alaska (907) 271-4500
Southeast Alaska (907) 586-7669

ntinental USA/Canada: (Regional recording numbers)

Colorado	(303) 236-9435
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Washington	(206) 527-6677
Alberta	(403) 762-3600

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